

Urban biotopes:

The typical and unique habitats of city environments and their natural analogues

Maria Ignatieva

Environmental Management and Design Division, PO Box 84, Lincoln University

Colin Meurk and Claire Newell

Landcare Research, PO Box 69, Lincoln

Christchurch City was founded in 1850. The original vegetation of the area where the city was developed consisted of wetland plant communities dominated by New Zealand flax (*Phormium tenax*), rushes (*Juncus* spp.), sedges (*Carex* spp.), reeds (*Typha*), and scattered cabbage trees (*Cordyline*), also tussocks (*Poa*), and pockets of shrubs (e.g., *Coprosma*) and small trees such as kowhai, (*Sophora*) kanuka (*Kunzea*) and matagouri (*Discaria*) on drier ground. Only Riccarton and Papanui Bush represented the classical climax forest of the moist plains dominated by kahikatea (*Dacrycarpus dacrydioides*).

Europeans created private gardens, public parks and pastures using familiar European plants and English models of landscape design. Picturesque (idealised landscape with rolling hills, cut lawns and small groves of European deciduous trees) and gardenesque (opposite to picturesque, using exotic trees and shrubs from around the world, colourful flowers in bedding, topiary) ideas were adopted in Christchurch.

At the outset because of natural conditions (empty, windy treeless plains, and local wetland character of the landscape) the hedge and shelterbelts were developed as a crucial type of protection. Pasture (the herbaceous type of vegetation based on exotic grass mixtures) and garden lawns have also played a leading role in the urban landscape.

As a result of urbanisation all of the original plant communities were destroyed (except for Riccarton Bush which from early years was declared as a reserve). Native vegetation was replaced by different types of urban plant communities that consisted mostly of exotic species. New plants arrived in Christchurch via three ways:

1. Deliberately introduced decorative, shelter, timber and edible species that were planted in orchards, gardens, parks and pasture. Later many of them escaped from cultivation.
2. Weeds that accidentally arrived with different seed mixtures and soil.
3. Weeds that were attached to clothing and animal wool, fur and feathers.

In 1998-2000 the vegetation of Christchurch was broadly stratified according to the European biotope concept. Biotope (from Greek bios-life and topos-place) is a section of the earth's surface (terrestrial or water) with similar abiotic environment with its characteristic plant community (Mirkin and Rosenberg 1983). This term is similar to 'habitat' which refers to the locality or external environment (vegetation) in which a plant or animal lives. Our understanding of urban biotopes is the cultural or urban equivalent of plant community habitats. Biotopes are basically the same as the ecological units of the Protected Natural Areas (PNA) survey of New Zealand. That is, they are definable entities with homogeneous attributes of environment, substrate, management or land use, and vegetation structure.

Investigation of Christchurch biotopes was based on sampling uniform areas where we recorded species composition, abundance, and features of the physical environment. Plant species abundance was scored on a scale of 1 to 6 where: 1 - species is rare (<1% cover), 2 - occasional (1-5%), 3 - locally abundant (6-25%), 4 - common (26-50%), 5 - abundant (51-75%), 6 - dominant (76-100). Physical environmental parameters included:

Land system: coastal, dry alluvial, moist alluvial, hill.

Landform: flat, hummock, gorge, terrace, hollow, cliff, slope, ridge, ledge, scarp, crest, crevice/crack, bank, gully, floodplain

Soil series: Kairaki, Kaiapoi, Heathcote, Wakanui, Waikuku, Tai Tapu, Horotane, Temuka, Selwyn, Waimairi, Templeton, Motukarara, Waimakariri, Halkett, Eyre, Te Kakahi

Texture: silt, sand, stones, boulders, rock

Surface type: semi-natural degraded, built, artificial

Artificial substrate: fill/soil, rubble, tip, compacted, brick wall, stone wall, concrete, asphalt

Condition: irrigated, cultivated, topdressed,

Soil pH: field indicator test

Comparative data from some European urban biotopes (temperate cities) was included (Allen 1965-67, Wiltshire 1994, Ignatieva 1987). Multivariate analyses (classification, ordination and multiple regression) were carried out. The principal ordination gradients were expressed in terms of sites and species distributions in ecological space. Sites or species close to one another are similar in species composition or in ecological role respectively. The order of sites and species along the axes of variation reflect controlling environmental gradients.

Preliminary Results

Seven biotopes were identified in Christchurch: lawns, wastelands, herbaceous (flower) borders, shrubberies and hedges, parklands and street trees, and pavement cracks and walls. All these urban biotopes are dominated by Eurasian species of similar habitats. From the total of 317 vascular plant species, only 48 are native, but this represents an average number of 2.3 per site (e.g. *Cordyline*, *Hydrocotyle*) and all of the 30 sites had at least one indigenous species. In contrast, European examples of biotopes comprise over 90% indigenous species. Nevertheless, the New Zealand samples retain some identity because a few species have adapted to urban environments and occur only in New Zealand (*Coprosma robusta*, *Cordyline australis*, *Cotula australis*, *Dichondra brevifolia*,

Gnaphalium audax, *Hebe salicifolia*, *Hydrocotyle heteromeria*, *Hydrocotyle moschata*, *Hydrocotyle novae-zelandiae*, *Juncus distegus*, *Juncus pallidus*, *Pteridium esculentum*, *Senecio glomeratus*, *Senecio minimus*). Note, however that biotopes of warm, temperate cities in the upper North Island have a greater range of exotic and subtropical species including C4 grasses (Esler 1988).

The presence of native species demonstrates the resilience of indigenous species even in the most modified environments. About 90% of the naturalised species of European and other overseas origin, that were found in Christchurch, were registered in similar habitats in European cities (London, Berlin, St.Petersburg). This demonstrates the process of global homogenisation of urban floras.

While there are natural analogues of urban biotopes clearly visible in Europe, in the case of Christchurch predominantly English settlers strove to survive and create familiar and productive plant communities of their home countries. Exotic plants arrived deliberately and accidentally. There are no prototypes of the predominantly exotic urban biotopes in New Zealand natural environments. Nevertheless, the native species that inhabit New Zealand cities have colonised from similar wild environments and it is possible to model approximate analogues of some urban biotopes from Eurasian landscapes.

Lawns are the most frequent type of biotope in Christchurch (average number = 18.1 species), and are characterised by absolute domination of exotic grasses. Dominants: *Trifolium repens*, *Bromus willdenowii*, *Poa annua*, *Taraxacum officinale*, *Bellis perennis*, *Achillea millefolium*, *Hypochoeris radicata*, *Crepis capillaris*, *Festuca rubra*, *Poa pratensis*, *Lolium perenne*. There are 16 native species in Christchurch lawns. They are uncommon with normally only 2 or 3 at any particular site. *Hydrocotyle* spp., *Cotula australis*, *Oxalis exilis* and *Leptinella* spp. are the most frequent.

The first lawns were probably well maintained fields in Europe used for grazing cattle and sheep, but also as a setting for ornamental trees and shrubs. The lawn prototype is probably natural European landscape-floodplain meadow vegetation. Lawns probably first appeared in the 13th century (Gorishina and Ignatieva 2000) but the precise time of their appearance is unknown. Bird-grazed lakeshore or riparian turfs may be seen as the New Zealand analogue (version) of the lawn (cut, smooth surface).

The lawn reflects all the variations in the local environment and the history of the garden. One of the classical examples is the Great Lawn in Chatsworth Historical Park that was sown by Capability Brown around 1760. This lawn has never been sprayed or fertilized, and deer grazing was replaced by mowing in 1833. Today this lawn is represented by a series of herbaceous communities including some of wildflowers which are not normally grown in lawns such as tormentil, lady's bedstraw, speed-well and violet (Gillbert 1989).

There is a new vision in the Northern Hemisphere of ecologically friendly lawns. "Freedom lawns" are seen as an alternative that allow natural and unrestricted growth of grasses, clover and wildflowers (Bormann *et al.* 1993).

In Christchurch, lawns are found mostly in parks, private gardens, playing fields, golf courses and along roads. In private gardens lawns may cover at least 50-60% of the area, in public parks it could be 75%. According to the Christchurch City Council the most common lawn mixtures are: *Lolium perenne*, *Festuca rubra*, *Agrostis capillaris*, *Poa pratensis*, *Bromus willdenowii* and *Trifolium repens*. These sown species dominate Christchurch lawns with the invasion of *Poa annua* and rosette weeds such as *Crepis capillaris*, *Achillea millefolium*, *Bellis perennis*, *Erodium cicutarium*, *Plantago lanceolata* and *Taraxacum officinale*. Christchurch lawns share many species with European lawns even with cities situated in quite cold climates (Muller 1990).

There are alternative ways to create environmentally friendly lawns that could contribute to ecological integrity in Christchurch, while it seeks a post-colonial identity. Dry alternative lawns may be achieved by planting in plugs of native mat, rosette and rhizome plants excluding fertilizers, herbicides, irrigation and aggressive exotic grasses while maintaining a high stress level through frequent disturbance by mowing (or grazing). Wet alternative lawns can be achieved in the same way as dry alternative lawn but with irrigation, allowing a different native suite of species to grow.

Wastelands are previously disturbed sites that have become neglected. There are three main types in Christchurch: neglected private gardens, construction areas with frequent disturbances, and ruderal sites in the industrial zone spontaneously colonised by plants and exhibiting different stages of succession. They are characterised by domination of exotic species (43.7 species): *Trifolium repens*, *Bromus willdenowii*, *Achillea millefolium*, *Conyza* spp., *Holcus lanatus*, *Taraxacum officinale*, *Crepis capillaris*, *Agrostis capillaris*, *Lolium perenne*, *Rumex obtusifolius*, and *Senecio glomeratus*. Among the natives are *Gnaphalium audax*, *Cordyline australis*, *Cotula australis* and *Pseudognaphalium luteo-album*. The prototype in natural vegetation is probably pioneer, disturbed sites in Eurasia or riverbeds in New Zealand.

Shrubberies and hedges are a special habitat created by planting trees or shrubs in a line or in small dense groups, a short distance from each other. There are both short and tall hedges; formal (cut) and informal types. The average number of species is 25.7.

The most common species for hedges in Christchurch are exotic *Photinia glabra*, *Camelia japonica*, *Ligustrum* spp., *Cupressus macrocarpa*, and *Ulex europaeus*. Up to 10-20% of small trees in urban shrubberies are indigenous species including *Olearia paniculata*, *Pittosporum tenuifolium*, *Dodonaea viscosa*, *Hebe* spp. and *Cordyline australis*. Many weeds of climbing character use trees and shrubs to support their development such as *Calystegia sepium*, *Galium aparine*, and *Hedera helix*. Sometimes the native *Muehlenbeckia* can be observed. There are some exotic grasses (*Elytrigia repens*, *Euphorbia peplus*, *Coronopus didymus*) that use the space under the shrub's canopy. Some European hedges have centuries of history and are often vital habitat for wildlife.

Forest margins and coastal or wind-exposed cliff edges could be natural analogues.

Flower borders are a very synthetic biotope whose analogues in nature are simplified alpine and different types of Eurasian natural meadows, coastal or Mediterranean herbfields and woodlands with ground covers of herbaceous species with decorative flowers, and also dry rocky habitats of South Africa and Mexico. The flowerbed is characterised by domination of exotic herbaceous plants and occasionally subshrubs with decorative flowers or foliage. Floristic composition (planted decorative exotics and invasive weeds) in Christchurch is almost identical to the flower borders of European cities. For example: *Tagetes*, *Geranium*, *Petunia*, *Narcissus*, *Lilium* and roses.

The average number of species is 26.3 in our few samples but the cumulative total for the urban environment would be considerably higher. The commonest spontaneous weeds for Christchurch borders are: *Euphorbia peplus*, *Sonchus oleraceus*, *Oxalis* spp., *Senecio vulgaris*, and *Poa annua*. A very important feature of this habitat is regular disturbance by cultivation, weeding, irrigation, and fertiliser.

Parklands and street trees in Christchurch are characterised by combinations of lawn and shrubbery/woodland. Average number of species is 24.6. Dominant species are European deciduous trees (*Quercus robur*, *Acer pseudoplatanus*, *Ulmus* spp., *Tilia x vulgaris*) standing above grasses (*Lolium perenne*, *Bromus willdenowii*, *Poa annua*), broadleaved herbs (*Trifolium repens*, *Stellaria media*, *Taraxacum officinale*) and sometimes planted spring bulbs (*Narcissus*). Native species can be observed as single individuals or in groups: *Pittosporum eugenoides*, *Plagianthus regius*, *Griselinia littoralis*, *Sophora microphylla* and *Cordyline australis*.

Walls have the lowest number of species (8.6). There was only one native species that appeared quite often - *Pteridium esculentum*. Recently *Blechnum penna-marina* was observed on an inner city damp wall. The European fern *Dryopteris filix-mas* and Eurasian *Cymbalaria muralis* (ivy-leaved toadflax) are the commonest wall plants in Christchurch and other New Zealand cities. These species are also the commonest wall plants in European cities. Other frequent species in Christchurch walls are *Linaria purpurea*, *Stellaria media*, *Taraxacum officinale* and *Poa annua*. In nature, steep cliffs are probably the closest biotope to urban walls.

Pavement cracks (13.6 species) commonly contain native species such as *Cordyline australis* and *Cotula australis* but are dominated by exotics such as *Poa annua*, *Sonchus oleraceus*, *Conyza* spp., *Sysimbrium officinale*, *Bromus willdenowii* and *Taraxacum officinale*. *Cordyline* is frequently found in pavement cracks and is a major asphalt 'destroyer', a role that birch and poplar play in Europe.

Rock edges and platforms are the closest natural analogues. Wall and crack plants have excited interest among botanists for at least 200 years (Woodell 1979).

Preliminary multivariate analyses (classification, ordination and multiple regression) of urban biotopes in Christchurch (Figs. 1-3) has shown that:

Fig. 1. Ordination of c. 50 vegetation sample sites for Christchurch, Dunedin and Europe. Common letters belong to sites classified as floristically related or similar. Sites enclosed by lines are the broad biotopes described in the text.

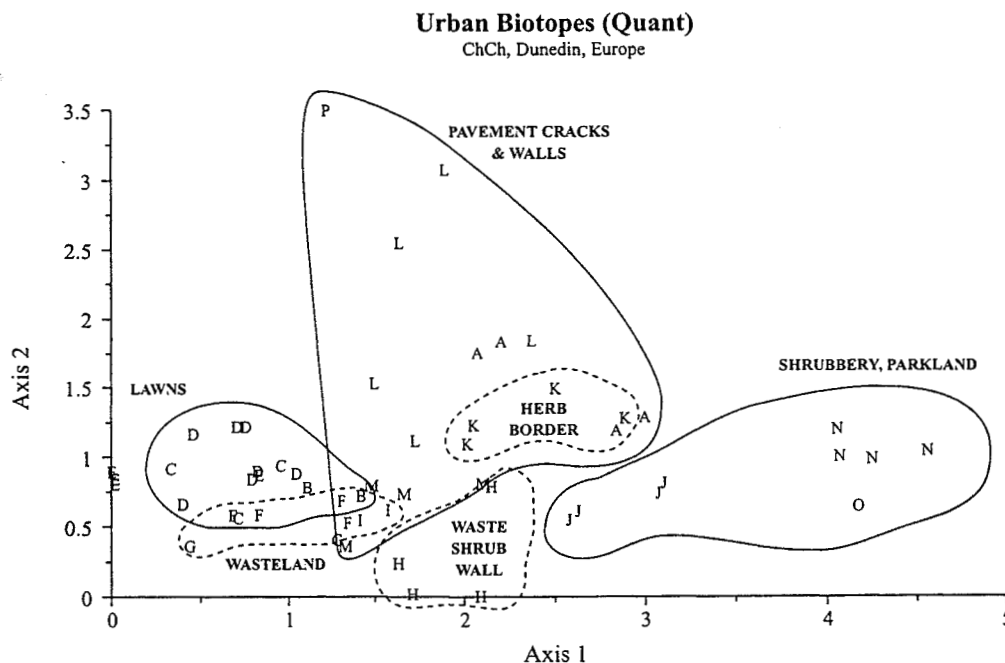
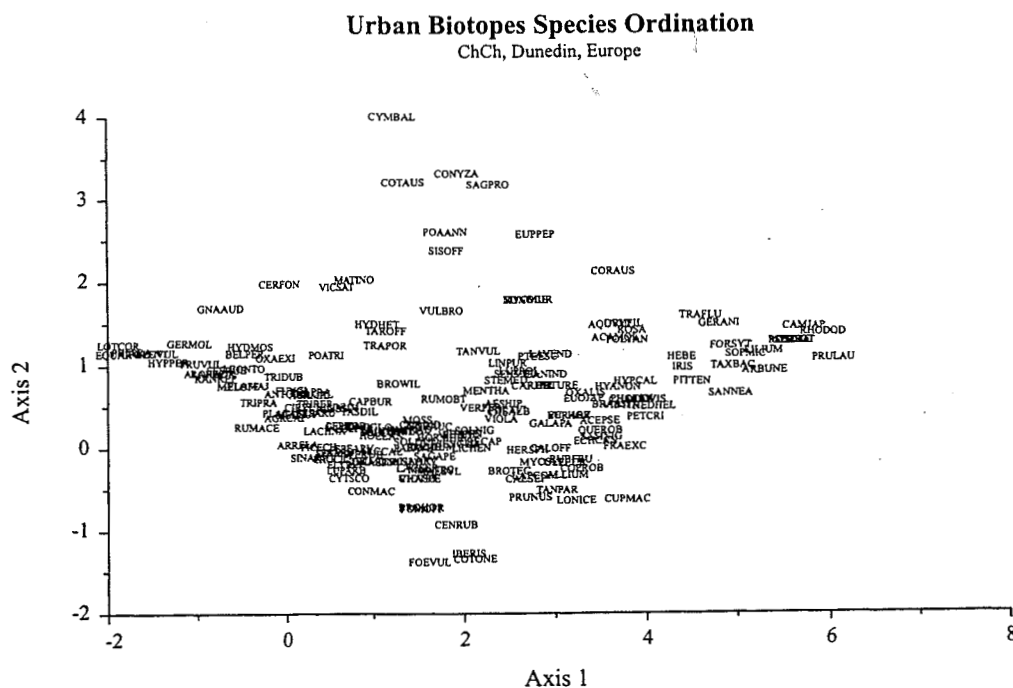
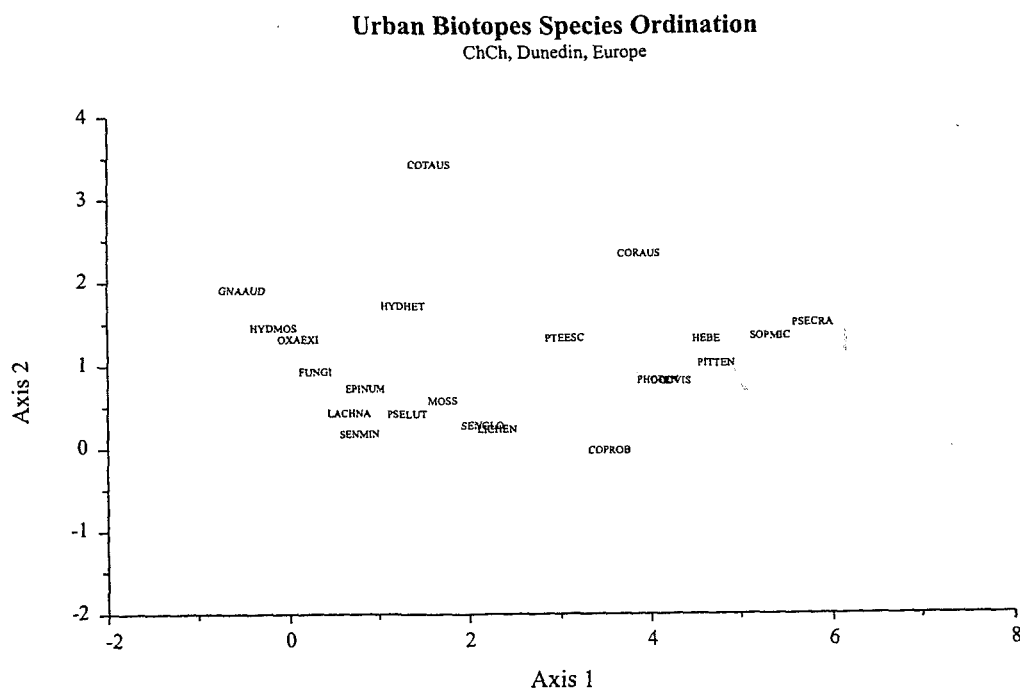


Fig. 2. Ordination of species in parallel with the site ordination (Fig. 1.) Species code names are derived from the first three letters of the genus name followed by the first three letters of the specific epithet (e.g., SAGPRO = *Sagina procumbens*) or in some cases the first six letters of a genus where several spp. are lumped (e.g., RHODOD = *Rhododendron* spp.).



- There is a principal source of variation (Axis 1) in stature (lawns to shrubbery and parkland) characterised by *Lotus*, *Prunella vulgaris* and *Hydrocotyle* spp. To the left and *Rhododendron*, *Prunus* spp., *Camelia japonica* on the right (Fig.1, 2).
- Secondary variation (Axis 2) is dense/closed vegetation with high competition, to sparse/open/high stress/low competition vegetation (cracks, walls) characterised, for example by *Cotoneaster foeniculum*, and *Conium maculatum* at the base and *Cymbalaria muralis*, *Conyza* spp. and *Sagina procumbens* at the top.
- Cracks and walls lie in the centre of the ordination as they draw in species from both lawns on one side and gardens/shrubberies on the other.
- Stature, species richness and soil pH explain a significant proportion of the variation in vegetation gradients. These are related to seral status and degree of competition with open/low cover sites (pavement and wall cracks) drawing in species from other communities at least as juveniles.

Fig. 3. Ordination of species in parallel with the site ordination (Fig. 1.) but including only the indigenous spp. COTAUS = *Cotula australis*, COPROB = *Coprosma robusta*, GNAAUD = *Gnaphalium audax*, PSECRA = *Pseudopanax crassifolius*, etc.



There is scope for deliberately increasing indigenous biodiversity within the context of New Zealand urban biotopes - in lawns, parklands, shrubberies, and herbaceous borders. As the proportion of indigenous species increases in restored urban habitats or formal plantings, wastelands and hard surface cracks, etc., are more likely to become colonised by such species (Fig. 3).

Acknowledgements

We thank Kirsty Cullen for drawing the figures.

References

- Allen, D.E. 1965-67. The Flora of Hyde Park and Kensington Gardens, 1958-1962. *Proceedings of the Botanical Society of the British Isles* 6: 1-21.
- Bormann, F.H., Balmori, D., and G. Geballe. 1993. *Redesigning the American Lawn. A search for environmental harmony*. Yale University Press, New Haven.
- Esler, A. E. 1988. The naturalisation of plants in urban Auckland, New Zealand 6: Alien plants as weeds. *New Zealand Journal of Botany* 26: 585-618.
- Gorishina T.K, and M.E. Ignatieva. 2000. *Botanical excursions around the city*. Chimisdat, St. Petersburg. 152 p.
- Gilbert, O.L. 1989. *The ecology of urban environments*. Chapman and Hall, London.
- Ignatieva, M.E. 1987. Composition, analysis and principles of flora formation in a nonindustrial town: Pouschino, Moscow Region. Ph.D dissertation, Moscow State University.
- Mirkin, B.M., and G. S. Rosenberg. 1983. *Modern dictionary of phytocoenology*. Moscow Science. 134 pp.
- Muller, N. 1990. Lawns in German cities. A phytosociological comparison. Pages 209-222 In: *Urban ecology: Plants and plant communities in urban environments*, Sukopp, H. and S. Hejny (eds.), SPB Academic Publishing, The Hague.
- Wiltshire, E. 1994. The Flora of Hyde Park and Kensington Gardens, 1988-1993. *The London Naturalist* 73: 38-60.
- Woodell S. 1979. The flora of walls and pavings. Pages 135-137 In: *Nature in Cities*, I.J. Laurie (ed), Willen and Sons, Chichester.